THE UPPER COLORADO[1]

AMONG the most eminent services rendered by American geologists to the cause of science, there can be little hesitation in placing the labours of Lieut. Ives and Dr. Newberry as given to the world in their well-known Report on the Colorado country of the West. By pen and pencil they brought vividly before the eye and the imagination the structure and scenery of a region so singular and so stupendous in its memorials of slow prolonged subaerial erosion as not only to throw every other known district of the kind far into the shade, but to furnish proofs of the potency of river-excavation, which even the keenest advocates for the power of rain and rivers at first hesitated to believe. Since that Report appeared, however, additional and confirmatory illustrations of the same marvellous scenery have been published by other observers, notably by Hayden and Powell. The gorges of the Colorado, with walls sometimes more than a mile high and running for nearly five hundred miles across the tableland, are now more or less familiar, from descriptions and sketches, to the geologists of all countries. They are admitted, too, to be due, as Dr. Newberry first contended, to the gradual erosive action of the rivers by which they are traversed. The whole of this Colorado basin or plateau is justly regarded as the most magnificent example on the face of the globe of how much the land may have its features altered by the agency of running water.

In the present Report Dr. Newberry gives the results of a second exploration to the Colorado, but to a more northern or higher tract than that embraced in his previous journey. The Expedition took place as far back as 1859, and this Report was written and sent to the authorities by the beginning of May, 1860. At that time, however, the Civil War was impending, by which not only this publication but many others of importance were arrested. The recent surveys of the Department of the Interior and the Bureau of Engineers having called renewed attention to the Colorado region, Col. Macomb and Dr. Newberry have succeeded, at last, in inducing the authorities to print and circulate their account of the observations made by them seventeen years ago. It is a welcome contribution to the literature of the subject. Dr. Newberry, by his summary and his narrative of detail, combined with his clever lithographic sketches, presents us with so vivid a picture of the landscapes through which he has wandered and of the geological structure which has given them their character, that nothing further can be desired save a personal visit to the marvels themselves under his experienced guidance. Four of the most characteristic views are here reproduced as woodcuts.

Westwards from the Rocky Mountain ranges to the head of the Gulf of California the basin of the Colorado stretches as a vast plateau, broken by the transverse gorge of the Great Cañon, at the bottom of which, from 3,000 to 6,000 feet below the level of the plain, the river wanders to and fro for nearly 500 miles. The plateau is further marked by a succession of terraces ending in steep walls sometimes 1,000 feet or more in height, and by occasional isolated mountain areas which rise above the general level like islands from the sea. These various inequalities, however, when seen from any of the eminences bordering the plateau are almost lost in the vast sweep of the level plain. On all sides the table-land is surrounded with mountain-ranges which seem on the whole to have a meridional direction, so that the table-land itself would appear to be a tract which has somehow escaped plication during the movements by which the encircling ridges were formed. The isolated mountains on this plain, however, indicate the same north and south trend, are composed like these bounding ridges, and may be referred to the same series and to a similar mode of origin.

In that upper part of the Colorado plateau now described by Dr. Newberry we recognise the same geological formations as well as the same striking features of colour which have given its name to the chief river. The oldest rocks belong to the Carboniferous system. Thence up to strata believed to represent the earlier Tertiary series of Europe there is a continuous conformable development of stratified deposits. These strata spread out in horizontal sheets over the plateau. On the eastern and western margins they have been heaved up along the flanks of the mountain ridges, and here and there, where an isolated axis of elevation or a dislocation occurs on the plain, they have likewise been upturned. But for the most part they retain their horizontality, so that the lower formations are not seen, except where they have been cut into at the bottoms of the cañons. The Carboniferous limestones contain such characteristic brachiopods as *Productus semireticulatus*, *P. scabriculus*, *P. punctatus*, *Spirifer*, and *Athyris*. The earliest records of that region, therefore, are those of a sea-floor, which must have stretched eastwards across what is now the range of the Rocky Mountains towards the land which then lay over the site of the Eastern States. The thickening out of the marine limestones towards the west establishes this point in the ancient physical geography of the American continent. Above the Carboniferous limestones and shales lie a conformable series of bright red, green, and yellow sandstones, shales, and marls, which are regarded by Dr. Newberry as Triassic, and perhaps partly Jurassic, and which pass conformably upward into massive yellow and grey sandstones and green shales, which are placed on the horizon of the Lower Cretaceous rocks. These latter strata, containing many cycads and ferns, with other traces of terrestrial conditions, form the surface over an enormous area of the table-land. As they approach the broader valleys they end off in a steep cliff or bluff like a sea-wall, often cut along the edges into numerous detached tables, pinnacles, and quaintly-shaped outliers. The red strata underneath form the platform out of which the deep gorges have been eroded and their bright colours running in parallel stripes along the walls of the cañons and the faces of the isolated fragments and pillars give an extraordinary character to the fantastic forms into which the rocks have been worn.

The want of any evidence of disturbance from palæozoic up into older Tertiary time is dwelt upon by Dr. Newberry in this Report as showing the simplicity of the structure of this part of the continent. The facts which he brings forward help to make our ideas still clearer of the stages by which the present physiography of America has been reached. He demonstrates the truth of his previous conclusion that the region of the Colorado is one of vast erosion, and he gives some interesting indications of the extent of this denudation. He shows that the great plain with its surface of firm Lower Cretaceous sandstone was once covered by a continuous sheet of soft Middle and Upper Cretaceous shales, of which scattered mounds and millions of loose fossils are strewn over the plain, and which rise along its margin into an upper plateau overlooking the great tableland and presenting a steep escarpment towards it. These overlying strata are at least 2,000 feet thick. There cannot be any doubt, therefore, that previous to the erosion of the profound gorges the tableland was buried under 2,000 feet of soft strata, all of which have been removed except these fragmentary relics. Dr. Newberry satisfactorily disproves the notion that this denudation could have been effected by any violent current like those waves of translation which used to be called in to account for the existence and distribution of the glacial drift and erratic blocks. No one can read his pages without a conviction that he correctly regards the whole erosion of the Colorado region as one vast continuous process in which air, rain, frosts, and rivers have been the main agents.

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[1] Geological Report, by J. S. Newberry, M.D., of the United States Exploring Expedition under Captain J. N. Macomb, from Santa Fé, New Mexico, to the Junction of the Grand and Green Rivers of the Great Colorado of the West. (Washington, 1876.)

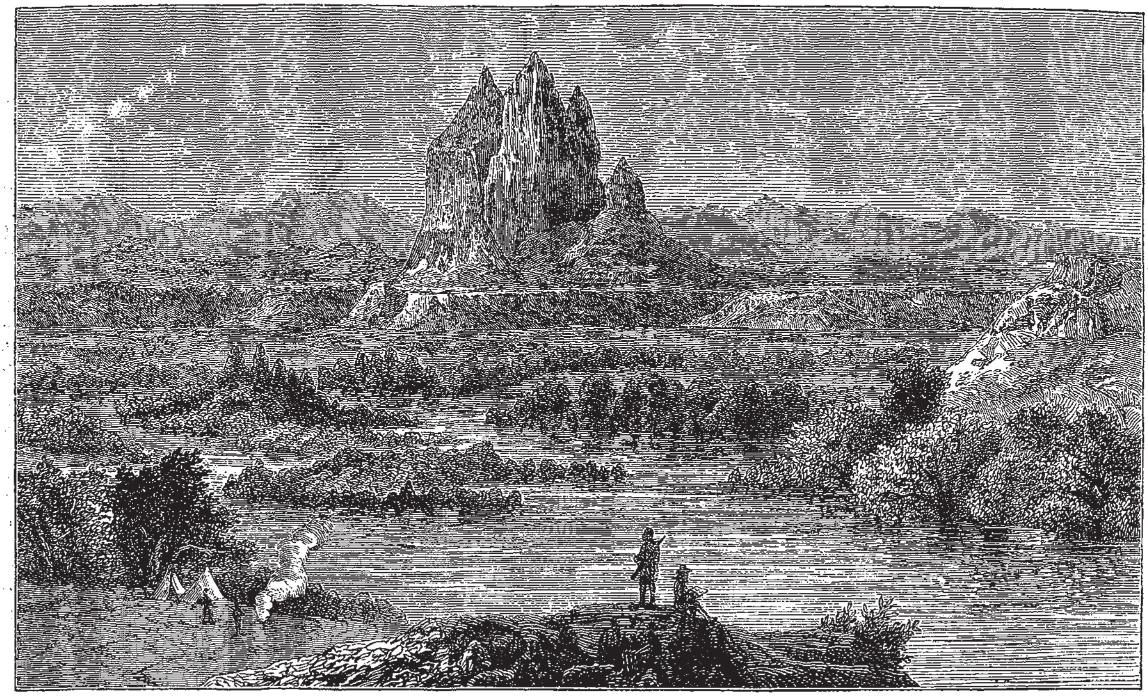

Fig. 1.—The Needles, looking South-westerly.

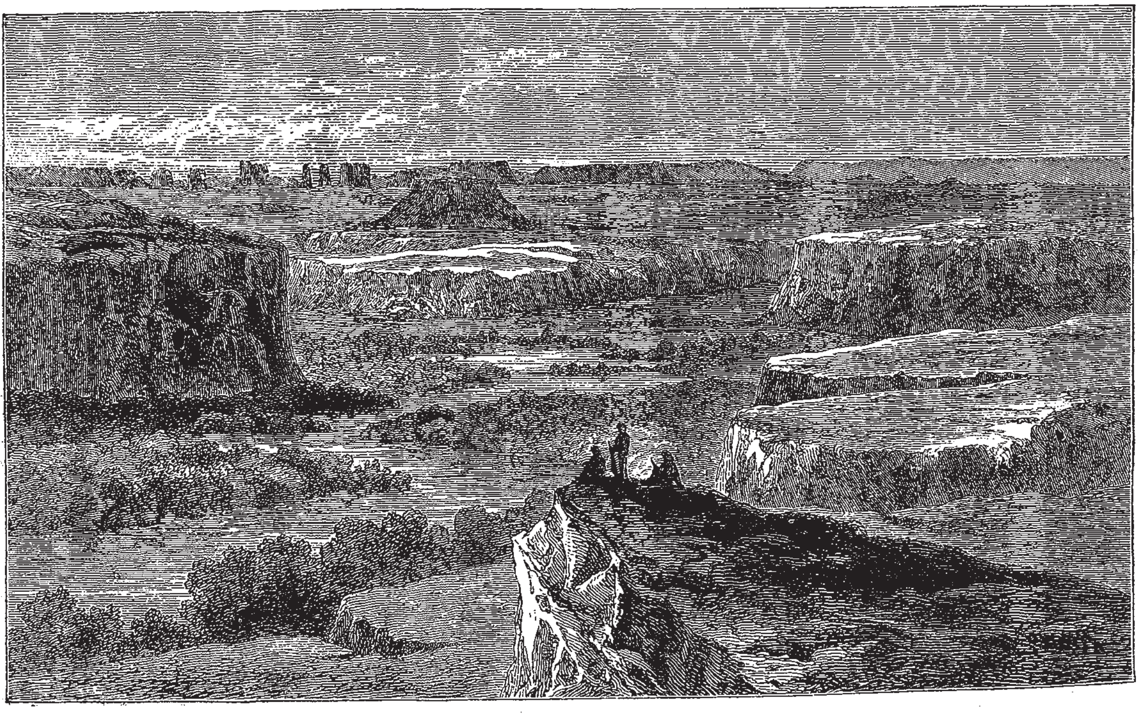

Fig. 2.—Lower San Juan, looking West.

The observations contained in this Report upon the structure of the isolated ridges which now and then disturb the horizontality of the stratified formations of the great plain are of considerable interest and importance. They show that the elevation of these ridges did not take place until after the deposition of the older Tertiary rocks, and that this elevation was not merely due to the protrusion of hypogene masses, but was part of a general and prolonged movement of plication by which the present axis of the North American continent was determined. The whole of the sedimentary formations ot the plain are found bent up against the granitic nucleus, which, like a wedge, has

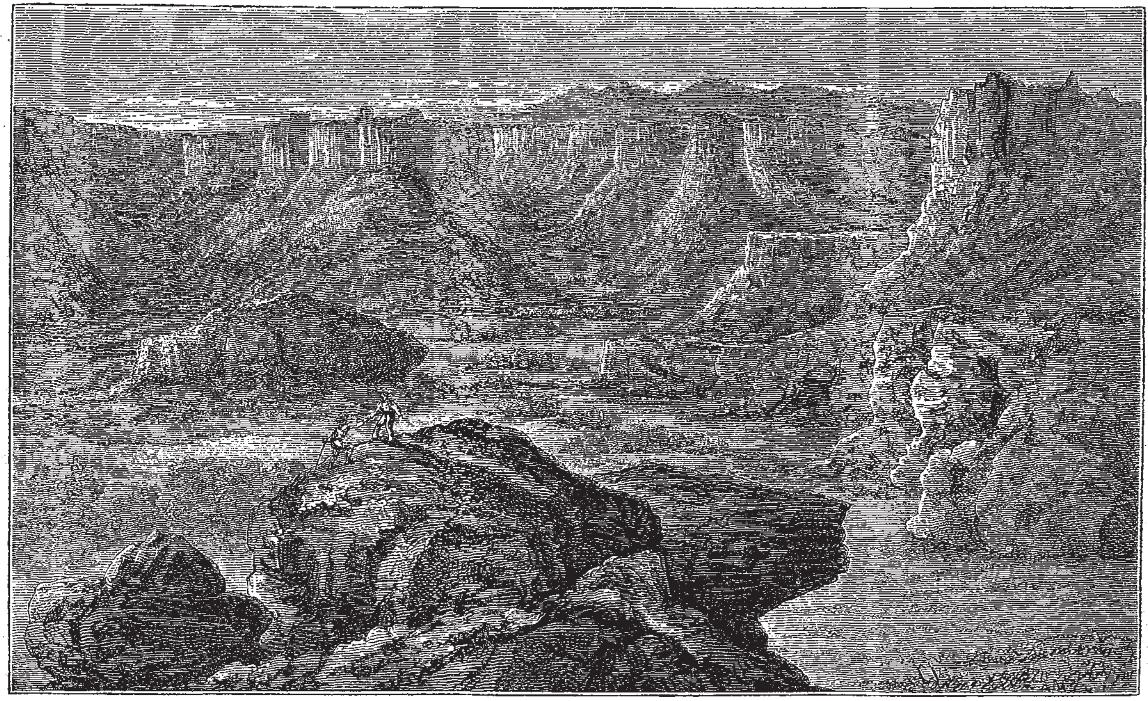

FIG. 3.—Head of Labyrinth Creek, looking South-easterly.

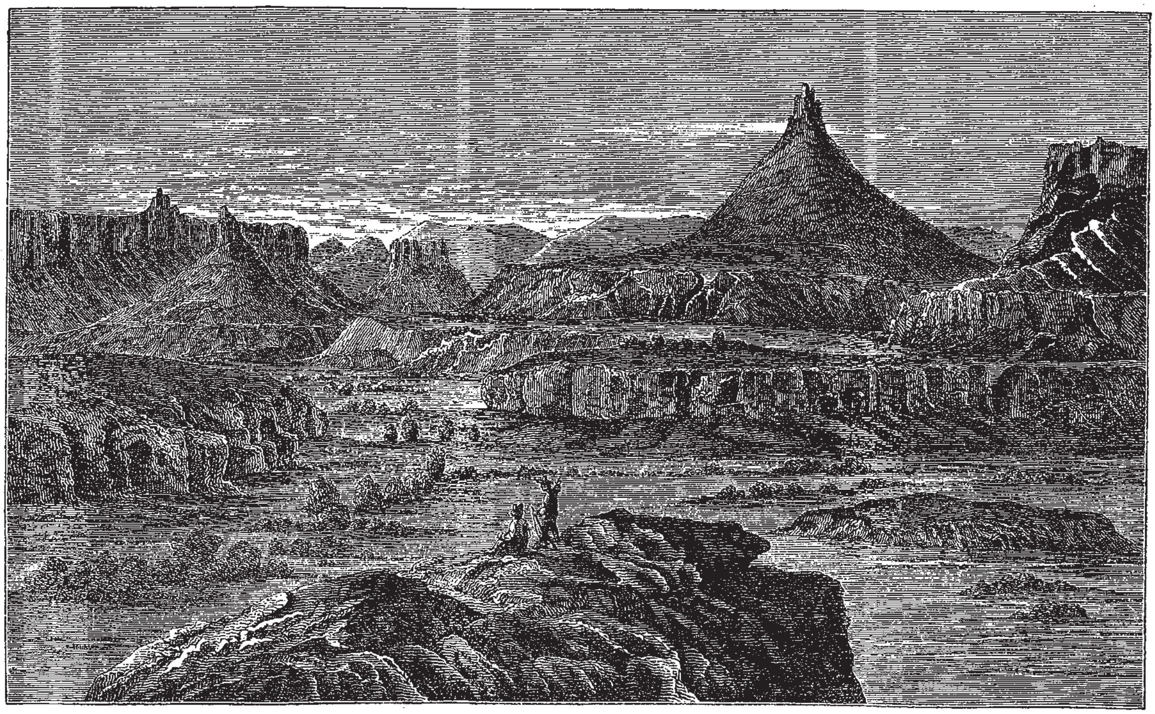

FIG. 4.—Head of Cañon, Colorado. Erosion of Triassic Series.

been driven through them. No proof of any such movement or of any volcanic action older in date than the Eocene, or Upper Cretaceous rocks, was obtained in this Expedition. So that we have here, apparently, an area where any subterranean movements which occurred never disturbed the conformable succession of deposits during that vast section of geological time from the Carboniferous (or even from the Silurian) up to the Eocene period. Whether the traces of terrestrial surfaces indicated by the plants and lignite beds of the Lower Cretaceous series, occurring as they do with marine strata below and above them, are to be regarded as marking oscillations of the crust, or as due merely to the gradual up-filling of the old sea-basin and its conversion into lagoons and terrestrial surfaces which were subsequently gently submerged again beneath the Middle and Upper Cretaceous seas, may be a question for discussion. It would seem that coincident with or subsequent to the pre-Miocene plication and upheaval, volcanic action began in the Western States. Dr. Newberry gives a drawing and a description of a singular basaltic rock called the Needles (Fig. 1) rising to a height of 1,700 feet above the Cretaceous floor of one of the tributary valleys of the San Juan, and regards this mass as having been intruded among the strata and as now left visible owing to its superior hardness, while the surrounding and overlying softer rocks have been washed away. But in his former Report in conjunction with Lieut. Ives, he showed the existence of a group of large extinct volcanoes in the San Francisco mountain group in Arizona, lying on the south side of the Colorado basin. The lava-streams are yet so fresh there that he supposes that the last eruption can hardly have taken place more than a comparatively few years ago. Considerably further to the east in New Mexico, San Mateo rises as another important extinct volcanic cone 11,000 or 12,000 feet high, whose most recent lavas are so fresh that "it is difficult to believe that they have been exposed to the action of the atmosphere even for so much as a hundred years." Dr. Newberry remarks that similar but smaller volcanic vents equally recent in appearance, but equally inactive now, are scattered over the entire area of the central tablelands from Mexico far up into the British possessions.

The author, who is an accomplished palæontologist as well as an active and gifted geologist, has added a valuable Appendix, in which he gives descriptions of the Carboniferous and Triassic fossils obtained by him in the course of the Expedition, and to which Mr. F. B. Meek[1] contributes an account of the Cretaceous fossils collected. It should be added, that besides the lithographic sketches the Report is enriched by some excellent plates of fossils.

ARCHIBALD GEIKIE

DEEP SEA MUDS[2]

II.

Peroxide of Manganese.

PEROXIDE of manganese occurs widely in ocean deposits, either as nodules, incrustations, or as depositions on the bottom itself. It has been found most frequently in the nodular form in the deep sea clays far from land. It also occurs in the organic oozes, when these contain much volcanic *débris*, or are near volcanic centres.

In shallow water, near some volcanic islands, it covers shells and pieces of coral or pumice with a light brown incrustation. It has been met with very sparingly, if at all, in shore deposits removed from volcanic centres.

In my preliminary report above referred to, I stated that further investigation might show that manganese nodules and depositions abound in these regions where we have much of the *débris* of augitic or heavy lavas.

A re examination of specimens since our return confirms this view. Wherever we have pumice containing much magnetite, olivine, augite, or hornblende, and these apparently undergoing decomposition and alteration, or where we have evidence of great showers of volcanic ash, there we find the manganese in greatest abundance. This correspondence between the distribution of the manganese and volcanic *débris* appears to me very significant of the origin of the former. I regard the manganese, as we find it, as one of the secondary products arising from the decomposition of volcanic minerals.

Manganese is as frequent as iron in lavas, being usually associated with it though in very much smaller amount. In magnetite and in some varieties of augite and hornblende the protoxide of iron is at times partially replaced by that of manganese.

In the manganese of these minerals and in the carbonic acid and oxygen of ocean waters we have the requisite conditions for the decomposition of the minerals, the solution of the manganese, and its subsequent deposition as a peroxide.

The carbonic acid converts the silicates of the protoxides of manganese, and the protoxides of manganese into carbonate of manganese, and thus prepares the way for oxidation by the oxygen of the water.

It is probable that the action of the carbonic acid is not apparent, and that the manganese is at once deposited as a high oxide if not as the peroxide. This theory is essentially the same as that which Bischof gives for manganese ores generally. I have laid a series of these manganese depositions on the table. An inspection of these and their localities will show that in the clays and oozes the depositions are nodular in form. If a section be made of one of these, a number of concentric layers will be observed arranged around a central nucleus—the same as in a urinary calculus. When the peroxide of manganese is removed by strong hydrochloric acid, there remains a clayey skeleton which still more strongly resembles a urinary calculus.

This skeleton contains crystals of olivine, quartz, augite, magnetite, or any other materials which were contained in the clay from which the nodule was taken. In the process of its deposition around a nucleus, the peroxide of manganese has inclosed and incorporated in the nodule the clay and crystals and other materials in which the nucleus was imbedded. The clayey skeleton thus varies with the clay or ooze in which it was formed. Those from a fine clay usually adhere well together; those from a globigerina ooze have an areolar appearance; those from a clay with many fine sandy particles usually fall to pieces. Mr. Buchanan informs me that the purest portions of these nodules, that is those portions made up of closely-packed concentric layers, contain from 30 to 34 per cent. of the peroxide.

Taking the nodule as a whole, it will of course contain very much less than this. The nucleus varies in each nodule, and that part of a nodule which is made up of concentric layers will vary with each locality and with the depth from which it comes. We may expect, therefore, that analysis will show considerable variations in the amount of alumina, silica, and metals, lime, &c., in the nodules from different stations. At some places in the Pacific the nodules show periods of deposition very distinctly. We have first a very compact nodule which may have a shark's tooth for a nucleus, and which appears to have been formed slowly. Then there would seem to have been a shower of ashes. After a time manganese was again deposited, inclosing in the nodule a layer of these ashes. The most frequent nucleus in the nodules is a piece of pumice or other volcanic fragment.

In deep sea clays, far from land, sharks' teeth, ear-bones of whales, and fragments of other bones are very often the nucleus around which the manganese is deposited. In one instance a piece of siliceous sponge forms the nucleus. In a globigerina ooze a portion of the deposit has apparently formed the nucleus. In these we have perfect casts of the foraminifera, but all the carbonate of lime has been removed. The volcanic fragments which have formed the nuclei of nodules appear frequently to have undergone peculiar alterations. For instance, obsidian is usually surrounded by beautiful agate bands.

When we found the bottom composed almost entirely of volcanic ashes, or so hard from other reasons that the sounding tube did not penetrate it, the manganese was deposited in layers over

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[1] Since this article was written, the announcement of Mr. Meek's death has reached this country. A more disastrous blow could not have been inflicted upon the progress of palæontology in the United States. It is much to be desired that amid the universal regret with which the death of this able palæontologist is received, some record shall be published of the services he has done. His numerous papers are scattered through so many publications (for he seems to have been ever at the call of any one who needed his assistance), that probably a comparatively small number even of palæontologists are aware of them all.

[2] "On the Distribution of Volcanic Débris over the Floor of the Ocean; its Character, Source, and some of the Products of its Disintegration and Decomposition," by Mr. John Murray. Read at the Royal Society, Edinburgh. Continued from p. 321.